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PB737- Commercial Tomato Production

The University of Tennessee Agricultural Extension Service

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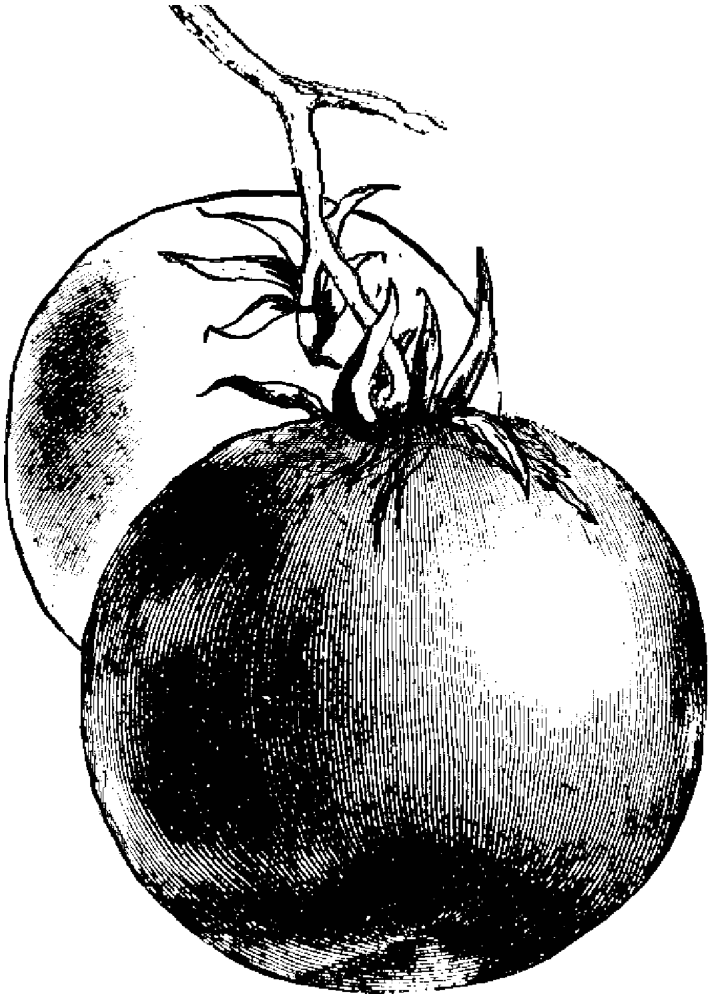
PB 737



Commercial Tomato Production

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Commercial tomato production requires a high level of management, large labor and capital inputs and close attention to detail. Tomato production is subject to the variations that occur in weather, which may result in severe crop damage and losses. Labor requirements for production, harvesting, grading, packaging and transporting are very intense. Prices can change daily when growers are dealing on the fresh market. Gross returns to top level growers range from $1,500 to $10,000 per acre. If you plan to enter the tomato business, be sure to first study these aspects thoroughly.

Three distinct production areas exist in Tennessee. In West Tennessee, tomatoes are produced primarily for early market, with plants supported by stakes in rows 5 to 6 feet apart. Producers in Rhea, Bledsoe and surrounding counties produce primarily for mid-season and late markets using the "Florida Weave System" and between-row spacings of 10 to 12 feet. East Tennessee growers produce for early, mid-season and late markets and practice many different ways of training and trellising.

Cultivars

Some markets prefer a red tomato when ripe, while others prefer one that is slightly pink on the blossom end when mature. However, some growers are now harvesting mature green tomatoes and treating them with ethylene to develop color in the fruit. The cultivars Sunny and Mountain Pride are considered the standard for the mature green market. The characteristics of several cultivars are summarized in Table 1.

Commercial growers who ship tomatoes long distances prefer a firm variety such as Mountain Pride or Sunny. Firm cultivars have thick walls that withstand long distance shipment without excessive deterioration. Growers who sell on local fresh markets may prefer either the firm or medium-firm cultivars. Such cultivars will normally sell on local markets, where the length of shelf life is not as important as in long distance shipment.

Determinate or Indeterminate Types

Determinate cultivars are self-topping, while indeterminate cultivars are not self-topping. Determinate cultivars require shorter stakes and less tying labor. Determinate cultivars are firmer than indeterminate cultivars and are better adapted to the handling and shipment requirements of packing shed operations. Determinate cultivars usually concentrate their fruit so the length of harvesting is greatly reduced compared to indeterminate types. The firmness of determinate fruits increases their desirability for slicing characteristics necessary in salad bar operations. Indeterminate fruits are usually softer than determinate and tend to separate when sliced. Therefore, indeterminate cultivars are better adapted to local, fresh market sales than to heavy handling or shipment. They will usually mature over a longer time than determinate types and are better suited to home gardens.

Determinate types are now the most widely grown commercial cultivars. As a result, indeterminate types will not be included in this publication.

Table 1

Tomato Cultivars for Tennessee

CULTIVAR	***COMMENTS AND CHARACTERISTICS[a]***
Determinate Types	**Determinate types can be used for both shipping and local fresh market sales. Because of their fruit firmness (flesh to gel ratio), they are primarily grown for shipping markets rather than direct, local sales.**
Carolina Gold	Good-flavored, determinate, yellow-fruited tomato. Has grey wall resistance.
Celebrity	Produces 7- to 8-oz. fruit that are deep and smooth. Generally does well in local sales. Soft for excessive handling. Has V, $F_{1,2}$, N and TMV resistance.
Mountain Delight	Firm-fruited shipper. Vigorous plant. V, $F_{1,2}$ resistant. Smooth fruit that are resistant to cracking and blossom-end-rot. Larger fruit than Mountain Pride.
Mountain Fresh	Large, oblate fruit that consistently produce a high percentage of 4x5 or 5x5 size. Resistant to cracking, blossom end rot and fruit puffiness. Very high yielder.
Mountain Pride	Very vigorous plant. Late-maturing, firm shipper. $VF_{1,2}$ resistance. Crack and grey wall resistant.
Mountain Spring	Has been a good-yielding cultivar with firm-fleshed fruit. Appears to have a low susceptibilityto cracking and blossom-end-rot. Has some tolerance to V,F.
Mountain Supreme	Mountain Supreme is one of the latest releases out of the North Carolina tomato breeding program. Its main feature is that it delays the onslaught of early blight. It is the only cultivar available which has significant early blight resistance. However, the fruit size is usually smaller than Celebrity. Requires suckering to increase fruit size.
Sunbeam	Considered mid-season. Large fruit. Has resistance to ASC, Fusarium $_{1,2}$, GLS, V_1
Sunpride	Has good packout of large fruit. Mid season. Has resistance to ASC. $FW_{1,2}$, GLS, V_1
Greenhouse tomatoes	**Greenhouse tomato production is expanding in Tennessee. With careful control of greenhouse construction cost, good site selection and ventilation capability, it is possible to profitably grow greenhouse tomatoes in both spring and fall. This extends the market opportunity for a grower over a longer season and maintains buyer interest when supplies are met. Soil production has been the main system used, but production in plastic bags and artificial media combined with drip irrigation is showing tremendous promise.**
Cabernet	Indeterminate. Large fruit, but may have green shoulders. Tolerant to V_1, $F_{1,2}$, N, ASC, TMV, and GLS.
Celebrity	Same as above. Has succeeded over the years for growers who use the soil.
Mountain Fresh	Same as above. Soil producers like the size for local retail sales.
Trust	Indeterminate. Good flavor. Slightly smaller fruit than Cabernet. Is presently producing 10-14 lbs./plant in the spring and 7-10 in the fall. No green shoulders. Resistant to TMV, C_5 , V, F_2 , FR.
Paste Types	
Hybrid 882	Pear-shaped fruit weighing 2.2-2.5 ounces and about 1.4 times longer than diameter. Listed as having resistance to V, $F_{1,2}$, ASC and BS.
Cherry Type, for Salad Bars	**With good market contacts and labor, cherry tomatoes can be a good specialty vegetable.**
Mountain Belle	New North Carolina release that is more uniform and slightly smaller than Cherry Grande. A very good-looking cherry type.

A = Subscript numbers ($_{1,2}$) indicate the disease strain or race to which resistance ocurs.
ALS = Alternaria Leaf Spot
ASC = Alternaria Stem Canker
BS = Bacterial Speck
F = Fusarium Wilt
FR = Fusarium Crown and Root Rot
GLS = Grey Leaf Spot
N = Nematodes
TMV = Tomato Mosaic Virus

Plants

Profits are increased by complete stands of stocky, disease-free plants. Plants can either be grown by the grower or bought from a reliable source. A certification label should be requested by growers for all purchased plants.

Homegrown Plants

High-quality plants are produced by using intensive management. **The most successful growers produce their own plants.** Light, temperature, humidity, moisture, fertilizer and soil must be properly combined so that disease organisms, insects and weeds are controlled. This results in the production of vigorous, stocky plants. Advantages realized by home-grown plants include:

- Plants of the desired cultivar.
- Plants that are ready for setting during optimum soil and weather conditions.
- Plants that produce a uniform stand, early growth and high yield.
- Greater control of diseases and insects.
- Better control of the size of root system.
- Higher early yields with container-grown plants.
- Better ability to produce hardened plants for early spring planting.

Certified Plants

Tomato plants are grown in certain areas of Florida, Georgia and Alabama and shipped north for transplanting. These transplant-producing areas have certification laws and inspection systems directed toward producing high-quality, disease-free plants. Therefore, tomato growers planning to buy their plants should observe the following precautions:

1. Buy plants carrying a certification label from the state in which they are grown. Growers should request certified plants with their order. Copies of the invoice should be kept in case problems arise at shipment.
2. Determine plant producer's reputation by asking for references from other growers who have used their plants for three or more years.
3. Accept shipment only if plants are of the correct size, cultivar, count and in good condition. Observe plants closely to be sure they have good foliage, terminal buds, root systems and have not been exposed to excessive drying. Generally, the larger the root system, the greater the yields.
4. Accept only pest-free plants.
5. Observe plants for symptoms of overheating in shipment. It is to the advantage of the grower to buy seed of the desired cultivar and send them to the plant producer for growing. This reduces potential mislabeling of desired cultivars.

Growing Plants

Using Commercial Growing Media

Commercially prepared mixes are available for growing plants. Such mixes usually contain sufficient fertilizer and lime to grow plants until they are transplanted to the field, but this should be determined before purchasing. They are formulated so they have a good water-holding capacity and proper aeration. They may not normally be sterilized.

Sterilization of Benches, Containers and Other Structures

Seed trays, benches, ground beds and other structural components should all be sterilized before use. Plastic seed trays can be dipped into or sprayed with a solution of one pound of copper sulfate per 25 gallons of water, but they should be thoroughly rinsed before using. A 10 percent solution of commercial bleach can also be used. Fibrous pots such as those manufactured from peat are not normally treated unless they are reused. Clay pots, sides and bottoms of hot beds or cold-frames, cross pieces and other structural components in contact with the growing media or plants should be treated. If thorough rinsing is not practiced after the application of bleach and sufficient time is not allowed before planting, injury to plants is likely to occur.

Float Trays

The advent of the "Float System" in the tobacco industry offers a new method of growing tomato transplants, especially for late production. Basically, the "Float System" consists of placing growing trays that will float and have 72 to 200 cells per tray on a nutrient-fortified water solution and growing plants there until they reach the desired transplanting height. If plants are to be grown in the spring, the water is kept warm and the bed is covered to provide protection against the weather and conserve heat while the plants are growing.

For each 50,000 plants, it could require three water heaters to successfully maintain the required growing temperature of the water. One problem with the trays is that they provide an insulation effect for the heated water. Late spring or summer plants can be successfully grown without extra heat in the water system, but seedlings and plants may need to have some shading during germination and early growth.

Plants to be grown in float trays are seeded about seven weeks ahead of the expected transplanting date and are transplanted to the float tray when the first true leaves are formed. The media available for tobacco plants seem to be very suitable for tomatoes. A water- soluble fertilizer such as 20-20-20 is used to grow the plants. Mix four to six ounces of the fertilizer per 100 gallons of water. Monitor the fertilizer concentration with a conductivity meter, and, if necessary, replace it proportionately as water is added back to the bed as a result of evaporation. Allow plants to germinate at about 75F and grow between temperatures of 60 to 70F, reducing the temperature and moisture.

For each 10,000 plants produced, it requires 50 of the 200-cell trays or 139 of the 72- cell trays. To prepare a bed with the required dimensions, figure each tray at 14 inches wide and 27 inches long. Table 2 provides guidelines for bed construction based on the number of plants desired when 200-cell trays are used. The 200-cell trays would be fine for a late crop of tomatoes, but it would be better to use a larger tray for early tomatoes because of the influence that cell size has on fruit earliness. To reduce algae growth during plant growth, be sure all of the growing area is filled with trays.

Figure 1

Diagram of a Float Tray used for tomato plant production

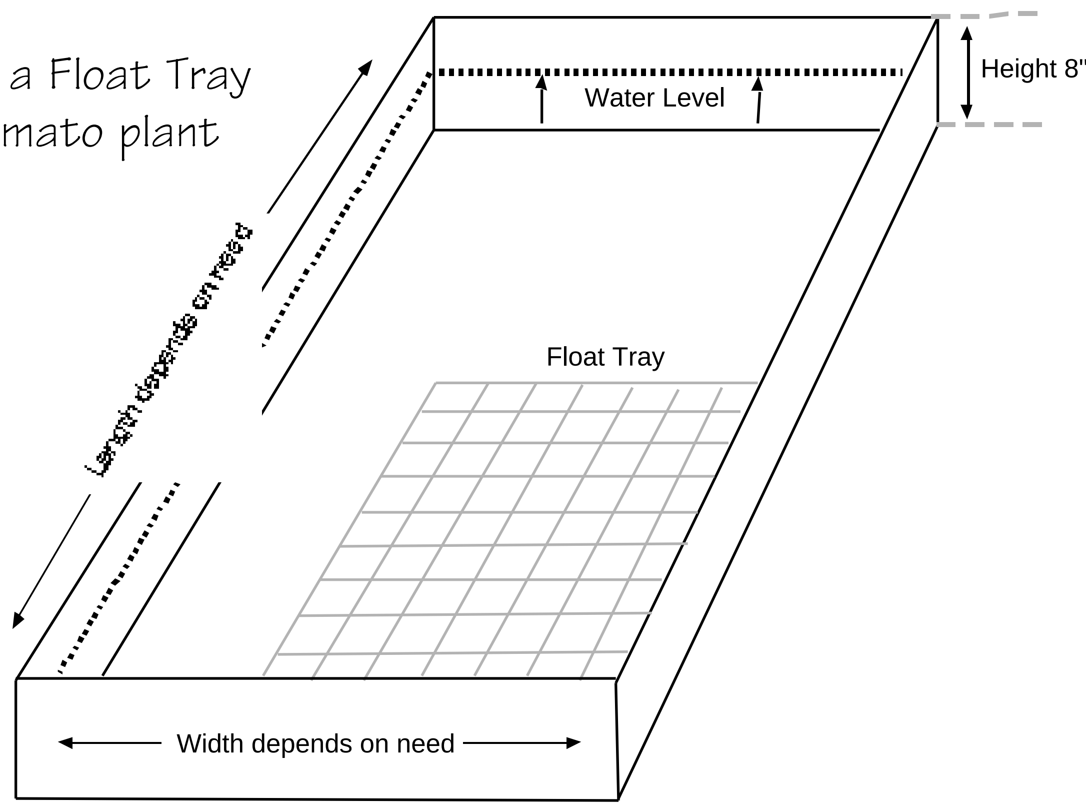


Table 2

Potential Float Bed Dimensions for Different Plant Quantities

Number of Plants Desired	Total Trays Required	Number of Trays Wide	Bed Width (ft)	Bed Length (ft)
10,000	50	4	5	29
		5	6	23
		6	7	19
25,000	125	4	5	71
		5	6	57
		6	7	47
50,000	250	4	5	141
		5	6	113
		6	7	94
75,000	375	4	5	211
		5	6	169
		6	7	141
100,000	500	4	5	282
		5	6	225
		6	7	188

Seeding

Tomatoes are usually seeded either by (1) vacuum seeding directly into growing containers or (2) hand seeding into trays and transplanting into the growing containers. Vacuum seeding eliminates the labor required for transplanting into growing containers, but some seeds fail to emerge and a certain percentage of seedling vigor is reduced. Compensation for these problems will need to be made by seeding about 15 to 20 percent more containers than needed.

Tomatoes are sometimes seeded in trays in a greenhouse or hot-bed. Seeds are sown in rows 2 inches apart with six to eight seeds per inch of row. They are then transplanted into containers when they are in the two-leaf stage. One ounce of seed contains 5,000 to 8,000 seeds.

Allow seven to eight weeks, except for float trays, from seeding to setting in the field. Plants grown in float trays will usually be ready for transplanting to the field one to two weeks before those grown in conventional trays. The approximate seeding dates for each area of the state are as follows:

West Tennessee	Middle Tennessee	East Tennessee
February 25 to March 1	March 1 to 10	March 5 to 15

Plant the seed to a depth of 1/4 to 1/2 inches, cover them lightly, press the soil with a flat board, moisten and cover the tray with glass or paper. Germinate at a temperature of 75 to 80F. When the young seedlings can be seen, remove the glass or paper.

For further information on plant production refer to Extension PB 819, *VegetableTransplant Production*, available through your county Agricultural Extension office.

Controlling Seedling Diseases

The following steps may be taken to reduce seedling diseases:

- Purchase fungicide-treated seed to reduce infestation of seed-borne diseases.
- Use commercial growing media. It is better if the media is sterile.
- Drench the media with a fungicide immediately after seeding.
- Avoid over-watering when growing in systems other than float trays. This creates highly humid conditions conducive to the growth of seedling diseases, particularly "damping-off."
- Maintain good air movement throughout the greenhouse or hotbed at all times. This is very important in controlling rapid plant growth, as well as keeping the growing media at a moisture level which does not encourage "damping off."
- Maintain temperatures in the 65 to 75F range during growth.

For chemical treatment of seedling diseases, use a treatment outlined in Extension PB 1282, *Commercial Vegetable Disease, Insect and Weed Control*, available at your county Agricultural Extension office.

Transplanting From Seed Trays

When seedlings started in seed trays have reached the two true-leaf stage, they should be transplanted to the desired containers. The first two leaves to appear are cotyledonary leaves and will fall off after the seedling becomes established. They have smooth leaf margins. The true-leaves appear after the cotyledonary leaves and have serrated leaf margins. Transplant when the true leaves have fully expanded, which occurs when plants are about 1.5 inches tall. When transplanting from the seed tray, gently loosen the seedlings by lifting them with a wooden label, broad knife or other similar tool. This avoids breaking of the roots and enables an earlier recovery. Move the seedlings by holding onto the leaves rather than the stems. Rough handling of the tender stems will result in bruise or breakage. Make a hole in the soil mixture with a wooden dowel or round peg about 3/4 inch in diameter and 3 to 4 inches long. Place the seedling 3/4 to 1 1/2 inches deep into the soil. Gently firm the soil with the fingers and place in partial shade for two or three days after transplanting.

Size of Transplant Containers

Research in Tennessee has shown that plants grown in 2 1/2-to 3-inch or larger containers produce a larger root system, bloom earlier and have higher early marketable yields than plants grown in smaller containers. This should be a major consideration for growers who wish to increase their potential for early market sales. Returns from higher early yields often offset the additional cost of larger containers. Total yields may not differ from plants grown in large containers versus those grown in smaller containers. Container size is not as important for late season tomatoes as for early markets.

Watering

Overwatering of plants grown with conventional methods results in soft, spindly plants. Keep the media moist, but not saturated. Wait until the media begins to dry before adding water.

Apply water during the morning so foliage will dry during the day. This helps prevent diseases. Use a fine nozzle sprinkler for watering. Do not apply enough pressure to the nozzle to splash soil on young seedlings or to knock them over. Water plants near aisles or walkways more heavily than plants in the center because they will dry more quickly than containers in the center aisles.

Growing Temperatures

Germinate tomatoes at 75-80F, but reduce the temperature for growing to 65-70F. This slows down the rate of growth and encourages the production of stocky, productive plants. This is a very important practice which results in good plants. It will require seven to eight weeks to grow the plants to field transplanting size under these conditions. Avoid allowing greenhouse temperatures to remain above 80F or greater during plant growth. Fruit set on the first clusters will be increased if the nighttime temperature is maintained between 55 and 60F for two or three weeks after full expansion of the cotyledonary leaves.

Light

Stocky, strong plants will develop when grown in full light. Subdued or reduced light results in elongated plants that have weak stems. These plants do not respond well when transplanted to the field.

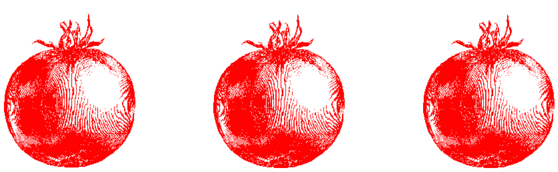
Ventilation

For greenhouses, thermostatically controlled fans and shutters, capable of changing the air once per minute is needed in one end of the house. For air intake, an opening twice the size of the fan is needed in the other end of the greenhouse.

In float beds where a transparent cover is used for plant protection, the cover should be raised or removed when temperatures inside the structure reach 75F. Raise the cover on cloudy, cool days and remove it on bright, warm days.

Hardening Plants for Field Setting

About a week before field setting, harden plants to withstand adverse weather by reducing the temperature 10 to 15 degrees, reducing water, increasing ventilation, providing full sunlight and spreading the plants. Hardened plants show a purplish color in the veins. If plants have a purple color between the veins, they have been overly hardened and will be stunted for a short time after setting. Hardening is of great importance for plants set in the cooler spring temperatures.



Minimum-Till Production

The university is not yet recommending minimum-till production for tomatoes although there have been some successful production demonstrations on late tomatoes with this production system. When properly done, minimum-till tomato production offers greater potential to produce on erodible land without serious erosion problems. To successfully complete minimum-till production requires that several practices be implemented. The vegetation must be killed prior to transplanting. Modifications to transplanters will need to be done to satisfactorily open and close a furrow for the transplant. This may include changing the press wheels, adding appropriate coulters and sufficient weight to the transplanter to produce a satisfactory furrow. If large root balls (greater than 1.75 inches diameter) are used, modifications in the handling fingers and the furrow opening shoes on the transplanter will be required.

Satisfactory transplanting requires that the soil be at a workable moisture level at the time of transplanting. This enables good furrow opening and closure to make firm contact around the root ball. It may be necessary, depending on the soil condition and the time of year, to run a subsoil unit at about half depth in the row prior to transplanting. This could be the situation if the field to be used has been in sod continuously for several years and transplanting is being made in June for a late crop.

Placing phosphate and potash in the root zone may be a problem. This is especially true where they are testing low. The addition of any recommended lime and phosphate will be difficult to work into the root zone because they do not readily leach downward with rainfall. If a cover crop is to be established in the fall prior to spring transplanting, lime, phosphate and a portion of the recommended potash could then be applied and worked into the soil. This provides better assurance that these nutrients will be available in the root zone. Another option is to broadcast them prior to transplanting. This option may work well in those fields where lime and phosphorus are high. Another option is modification of the transplanter to allow a band injection at the time of transplanting. Nitrogen and potassium can either be sidedressed or applied through a trickle irrigation system if adapted to the field. For information about this technique, refer to the section on “Fertigation” in this publication.

Weeds that escape through the existing mulch layer left by the kill of existing vegetation may require an application of a directed spray of materials such as metribuzin (Lexone, Sencor) during the growing season.

Growers who have tried minimum-till have indicated that the mulch layer makes fungicide/insecticide applications during wet weather much more practical. There is less tractor wheel slippage on slopes and traction is usually much better during normal growing operations than is common with conventional tillage. This enables better movement by both equipment and pickers during various operations.

Field Production Practices

Soils and Site

Soils recommended for tomato production contain good levels of organic matter, are well-drained and are not subject to flooding. The site should provide good air drainage to reduce damage from late spring or early fall frosts and the spread of fungus diseases during the growing season. Avoid sites that are infested with nematodes, or sites on which pepper, eggplant or Irish potatoes have been grown in the last three years. Avoid planting tomatoes behind crops which have long residual herbicides to which tomatoes are sensitive.

Fumigation

Fumigation is being practiced in some areas of Tennessee to control verticillium wilt, nematodes and certain weeds. Fumigation consists of (1) tilling the soil with a power rototiller, (2) injecting a methyl bromide-chloropicrin mixture 6 to 8 inches into the soil, (3) sealing the soil with plastic, and (4) plastic removal. The soil temperature should be 55F or greater at the point of injection. Plastic should be left on the soil at least 48 hours after treatment. Once removed, the soil should be stirred lightly and allowed to aerate for a minimum of five days. Fumigation requires special equipment and safety precautions and is quite expensive.

Fall fumigations are preferred over spring fumigations, but treatment at this time may not be practical because of the potential for erosion on sloping land, or the potential reinfestation of weeds if the plastic is removed. When spring fumigations are made, considerable aeration is needed after fumigation to lessen early yield reduction. The temperature conditions required for fumigation may delay planting when it is done in the spring. All plant residue must be fully decayed before applying the fumigant. Usually, about six weeks are required for plant debris to decay after turning.

Methyl bromide is the primary fumigant used for fumigation of land on which tomatoes are grown. There is an effort being made to ban methyl bromide for use as a fumigant in the next few years. At the present time, Telone and Vapam are materials available for alternate use. Methyl bromide is the most widely used because of its effectiveness. Efforts are underway to develop a suitable substitute.

Plastic disposal involved with fumigation may be a problem. Most of the plastic presently used is non-biodegradable. This makes its disposal limited because it will not be allowed in a landfill. Some states have considered the option of baling for recycling purposes, but this has not yet received wide adaptation. Biodegradable plastic is available and is being evaluated in some areas.

Fertilizer and Lime

With increasing use of black plastic and fertigation, there are three methods of applying fertilizer to tomatoes. One recommendation is for growers who grow their crop on bare ground. Another is for production on plastic without trickle irrigation, while the last is for those growers who use both plastic and trickle irrigation.

For bare-ground and production on plastic without trickle irrigation, apply lime, phosphorus and potassium according to soil test recommendations. This may mean applying recommended levels of N, P and K either as a broadcast application or in a band in the row area prior to transplanting in the case of bare-ground production. If plastic only is used, it may require application in a band the width of the plastic bed prior to plastic installation. For those who use both plastic and trickle irrigation, all of the recommended phosphate and one-half of the recommended nitrogen and potash should be applied prior to laying the plastic. The remaining one-half of each can be applied through the trickle system as suggested in the section of this publication that discusses fertigation. Recommendations are provided in the section on "Fertilizer."

Lime

The soil pH should be 6.1 — 6.5 for maximum production. When needed, apply and mix into the soil the recommended rates of finely ground limestone six weeks to six months ahead of the transplanting date. This gives sufficient time for the lime to react and alter the pH. A finely ground lime will raise the pH higher and faster than a coarsely ground product.

Lime applications are based on the soil pH. To reduce blossom-end-rot, the soil calcium levels should be maintained above 500 pounds per acre. Therefore, growers should always ask for a calcium analysis when requesting a soil test.

If low calcium levels exist, an imbalance in fertilizer uptake will occur and alter the normal growth rate of tomatoes.

Fertilizer

Recommended broadcast fertilizer levels are listed in Table 3. Growers using rows that are 10 to 12 feet apart need to apply fertilizer in a 2-or 3-foot strip in the row area. This rate can be adjusted to the linear feet of row (See Table 4) for the desired band width of the fertilizer application. For example, the amount of fertilizer is spread the entire length of row required at each band width to provide an acre of land.

Fertilizer recommendations from the soil test lab are given on a fertilized-acre basis. Thus, the table can be used to determine the row length needed to produce an acre.

When soil P and K levels are high, Tennessee research has shown no yield response when using more than 60 pounds of P or K. Therefore, growers should evaluate their soil nutrient levels and avoid excessive applications when it is unlikely that they can recover their costs.

Blossom-End-Rot

Tomato growers should be cautious about over fertilizing, due to the possibility of inducing blossom-end-rot. Blossom-end-rot can be induced by excessive nitrogen (especially ammonium nitrate), potassium or magnesium applications and a low ratio of calcium to other fertilizers in soils. It is also increased when insufficient moisture is present to move calcium into the plant. Thus, soils used for tomatoes should be analyzed for calcium. Sufficient levels should be present in the soil to reduce the chances for this disorder. In addition, uniform soil moisture should be maintained through the growing season.

Nitrogen

Ammonium nitrate, urea, calcium nitrate and sodium nitrate are nitrogen sources which are sometimes used for sidedressings. If growers have the proper soil calcium levels, ammonium nitrate is probably the best choice because it is less likely to be lost to evaporation and is inexpensive per pound of nitrogen. At a pH below 6.1, calcium nitrate will reduce the occurrence of blossom-end-rot, but calcium can be provided through lime more economically. The amount and time of nitrogen application is listed in Table 3.

Fertigation

Black plastic, in combination with trickle irrigation, is becoming a widespread production technique in Tennessee. If black plastic is used, sidedress nitrogen applications cannot effectively be made to the root zone. Phosphorus is practically insoluble in water, which inhibits application through a trickle system. All of the recommended phosphorus will need to be applied and worked into the soil before the plastic is laid. Potassium is soluble enough to be applied through the trickle system.

To effectively fertilize tomatoes grown on plastic, all of the phosphorus and about 50 percent of the recommended nitrogen and potassium should be applied before the plastic is laid. The remaining quantities of nitrogen and potassium should be split into weekly applications over the growing season. The weekly percentages should start at about 4 percent of the total and increase to about 7 percent during the peak of the season, then decrease back to about 4 percent during the late harvest stage.

Table 3

Recommended Fertilizer Rates (Pounds Per Acre)

Nitrogen++ Application		Phosphate (P_2O_5) Soil Test Levels[1]				Potash (K_2O) Soil Test Levels			
At Planting	Sidedressing	L	M	H	VH	L	M	H	VH
60	60	240	120	60	0	240	120	60	0

++ Apply when fruit on the first cluster are 1 inch in diameter and continue at three week intervals during harvest. Due to drier weather and cooler temperature, late tomatoes will not need as many total sidedressings as an early crop.

[1] L — Low; M — Medium; H — High; VH — Very High

In addition, the following recomendations are made:

1. If tomatoes are being grown on plastic with fertigation, **apply all of the recommended phosphate and one-half of the recommended nitrogen and potash prior to installing the plastic. Apply the remaining recommended level of nitrogen and potash in weekly intervals over the remainder of the growing season (8-12 weeks).**
2. Apply 500 pounds of calcium sulfate (gypsum) per acre when the water pH is 6.1 or above. If the water pH is less than 6.1, apply lime as recommended and omit the calcium sulfate.
3. (This recommendation is made only when a soil test indicates a need for magnesium). Apply 20 pounds of magnesium per acre using magnesium sulfate or potassium sulfate. If lime is needed, dolomitic limestone is recommended as the magnesium source since it can be used to correct both low magnesium and soil acidity.

Table 4

Linear Feet of Row Required to Obtain a Fertilized Acre when Varying Widths of Fertilizer are Used.

Fertilizer Band Width	Linear Feet
2 feet	21,780
3 feet	14,520
4 feet	10,890

Weed Control

Weeds compete with tomatoes for water, fertilizer and sunlight, as well as harboring insects and diseases. They greatly reduce harvesting efficiency, thereby increasing harvesting costs.

Fields that are infested with perennial weeds such as johnsongrass or bermudagrass should be (1) treated with Roundup the year before planting, (2) fumigated or (3) planted with crops that have good perennial weed control programs. Roundup is very effective in killing the roots of these perennial weeds and does not result in residual carryover. However, it will not control weeds from seed.

In recent years, great advancement in obtaining total season weed control in tomatoes has occurred. All chemicals should be applied at the times and rates given on the label. Some may be applied before planting, while others may be applied after planting. Certain herbicides applied before planting are usually effective in controlling grasses and a few broadleaf weeds, but they do not give total season control of johnsongrass, bermudagrass, barnyard grass, ragweed, lambsquarters, nutsedge or morningglories. With the advent of metribuzin (Lexone, Sencor), a method now exists to provide good control of many troublesome weeds. Metribuzin will burn down morningglories in the four-leaf stage, but it will not kill seed. Certain members of the nightshade family, such as hornsnettle and ground cherry, however, are not killed by this material. Poast now has label clearance for grass control in tomatoes. Read the label before applying any herbicide.

For current chemical weed control recommendations, refer to the current Extension publication PB 1282, *Commercial Vegetable Disease*, *Insect and Weed Control,* available at your county Agricultural Extension office.

Herbicides are not any more effective than the techniques used to apply them. It is extremely important that efforts be made to apply herbicides at uniform rates over the entire area to be treated. This includes using identical nozzle tips, adequate agitation and a proper combination of pressure and speed. Postemergence herbicides may require the addition of a surfactant. Spray calibration is of prime importance when applying materials at uniform rates.

If cultivation is used for weed control, cultivate shallow to avoid root damage and cultivate just ahead of a rain or irrigation.

Even though plastic provides good control of many weeds in the row, it will not eliminate nutgrass. Its use has now been adapted on about 40 percent of the tomato acreage grown in the state. Weed control between the rows of plastic may require directed applications of materials such as metribuzin or gramoxone.

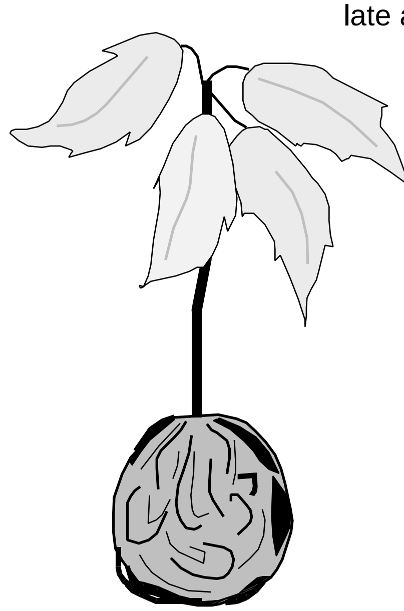
Setting in the Field

A few hours before setting, water the plants so their roots will not dry out during handling and to prevent crumbling of the soil from the roots of container-grown plants.

Usually, transplanters are used to set plants. Generally, mechanically transplanted plants have a higher survival rate than hand-set plants if water application attachments are used.

A high phosphate starter solution such as 10-52-17 in the transplant water enables a rapid plant start when the soil phosphate levels are low. This is important to obtaining early yields. If soil phosphate levels are high, starter solutions may not be necessary. Phosphate and potash levels can be determined by taking a soil test.

Set plants deeply so that only three or four leaves and the terminal buds are exposed. Planting deeply encourages lateral root formation along the buried stem, which gives plants a greater capacity to absorb both water and nutrients. Set plants in the late afternoon to reduce heat damage.



The ideal plant size for field setting is about 8 inches tall and 6 to 7 inches wide.

Black Plastic

An increasing number of growers are using black plastic for growing tomatoes. Fertilizer is applied ahead of laying the plastic. Trickle irrigation systems may also be laid under the plastic if desired. Plastic controls weeds and certain diseases, conserves moisture and increases both the quantity and quality of early marketable fruit.

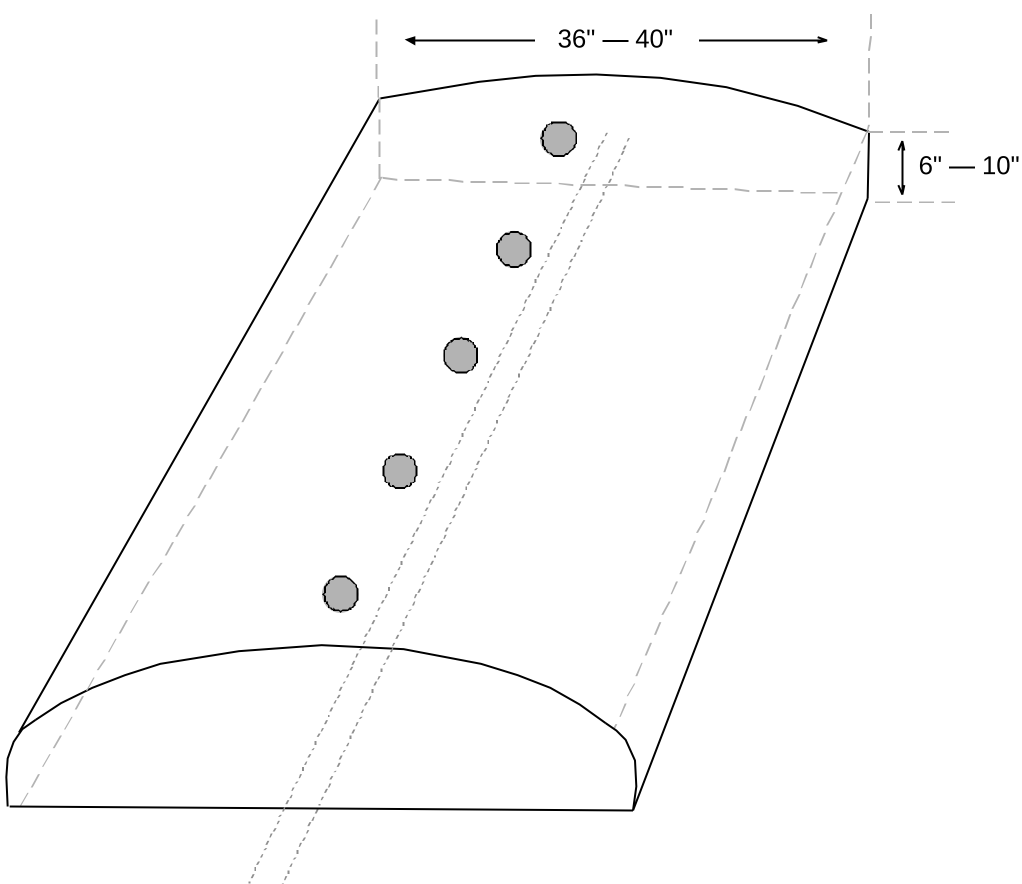
To effectively use plastic, the land must be in good condition with no sharp objects, stones or large clods to impede plastic installation or to punch unwanted holes through the plastic. Plastic is normally installed over a 6-to-10 inch high bed which has been shaped with a bed-shaper to enable well-formed shoulders. The bed is sloped downward about 1 inch from the center to the shoulders to enable good water drainage from the bed. The width of the plastic bed is approximately 36 inches and it is usually installed at a 5- or 6-foot distance from bed center to center.

Holes are normally punched through the plastic by a rolling water-wheel with spikes on the outer circumference to provide plants at the desired in-row spacing.

The major disadvantages of plastic are the expense to install, the labor required to remove and the disposal of the used material to satisfactorily meet the Environmental Protection Agency regulations.

Figure 2

Schematic of Plastic on a Raised Bed with a Trickle Line under the Plastic



Frost Protection of Plants

Growers who produce their own plants can use large diameter containers and hold them without early yield sacrifice until frost danger is past. **This is a better alternative than trying to provide frost protection in the field. It reduces the potential for producing a high percentage of cat-faced fruit due to cool temperatures that sometimes occurs when fruit are transplanted early in the field.**

Plants set in the field early can be protected from late spring frosts by using sprinkler irrigation, but a higher percentage of rough fruit may develop. If frost is expected, set up the irrigation system and check it to be sure it is operating properly. Set a thermometer at the lowest place in the field. When the temperature drops to 34F, turn on the irrigation system and leave it on until the ice has melted. Apply 1/10 to 1/15 inch of water per acre per hour using single-nozzle sprinklers, which operate at a pressure of about 15 pounds per square inch higher than nozzles normally used with irrigation.

For growers who are not equipped for irrigation and who have an acre or less, provisions should be made to cover the plants if frost is expected. Plants should be uncovered soon after the sun rises to prevent burning.

Plant Spacings and Prunings

Between-row spacings range from 4 to 6 feet in most areas of the state. However, spacings of 10 to 12 feet are used in the Walden's Ridge area of Rhea, Bledsoe and Grundy counties and in Lauderdale County.

Spacings within the row vary from 18 to 24 inches. When spacing is 18 to 24 inches within the row, pruning is generally done to two stems on the indeterminate cultivars. Determinate cultivars such as Mt. Pride or Sunny are pruned, at the most, only once or twice. If spacing is less than 18 inches, plants are pruned to one stem. Pruning will produce higher early yields and larger fruit than non-pruning, but total yields are often highest on non-pruned plants. Plants per acre required at different spacings are listed in Table 5.

Table 5

Plants per Acre for Different Row Spacings

In Row (Inches)	Between Row (Feet)	Plants Per Acre of Land	Linear Feet of Row Required
18	5	5,808	8,712
	6	4,840	7,260
	8	3,630	5,445
	10	2,904	4,356
	12	2,420	3,630
24	5	4,356	8,712
	6	3,630	7,260
	8	2,722	5,445
	10	2,178	4,356
	12	1,815	3,630
30	5	3,485	8,712
	6	2,904	7,260
	8	2,178	5,445
	10	1,742	4,356
	12	1,452	3,630

Training Systems

Tomatoes should be grown on supports. About 50 percent of ground-grown tomatoes will be lost to decay, sunscald and insects. Staked or trellised plants produce high-quality fruits, which are more easily sprayed and harvested.

Staking and Tying

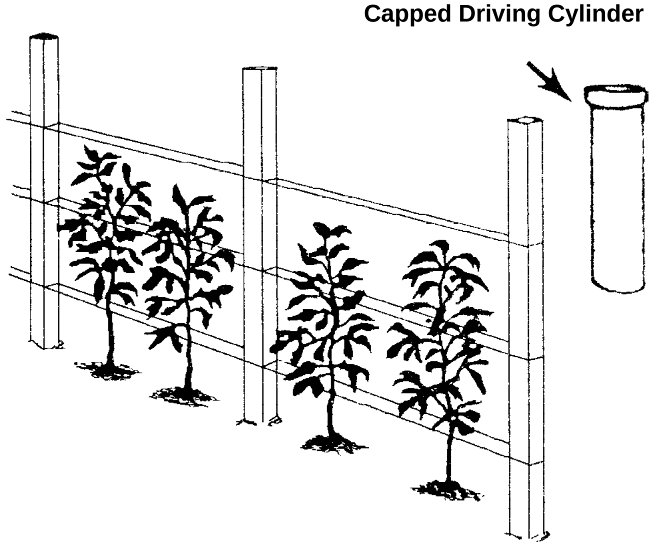
Staked tomatoes of the determinate type are trained using the "Florida Weave System," while indeterminate types are trained using individual stakes. Determinate cultivars require shorter stakes. Stakes are driven 10 to 12 inches in the ground. An effective method to drive stakes is to use a heavily capped, metal cylinder that is 3 or 4 inches in diameter and 18 to 24 inches long.

In the "Florida Weave System," two plants are spaced between each stake. This reduces stake driving and cost of stakes by 50 percent when compared to individual staking. Twine is used for tying. Nylon will not stretch as much as binder-twine. The first string is stretched parallel to and about 10 inches above the soil surface on one side of the stakes and repeated on the other side at the same height. With this training method, plants grow between and are supported by the two strings. The strings are wrapped around each stake and tightened to provide good support. Stringing is repeated about every 8 inches in height. Indeterminate varieties will require five to six stringings, while determinate varieties will require three to five. The "Weave" is most commonly used with determinate varieties.

With individual staking, stakes are driven at each plant. Plants are then tied loosely about every 8 inches up the stake. Pruning, if practiced, is normally done at the same time. Individual staking will provide better support and earlier yields of larger fruit than the Florida Weave, but it requires more stakes, labor and time and is now only used on less than 1 percent of 5,500 acres being grown.

Figure 3

The Florida Weave System



The Florida Weave: Two plants between stakes. The first string is app. 10 inches high. Stringing is repeated every 8 inches.

Irrigation

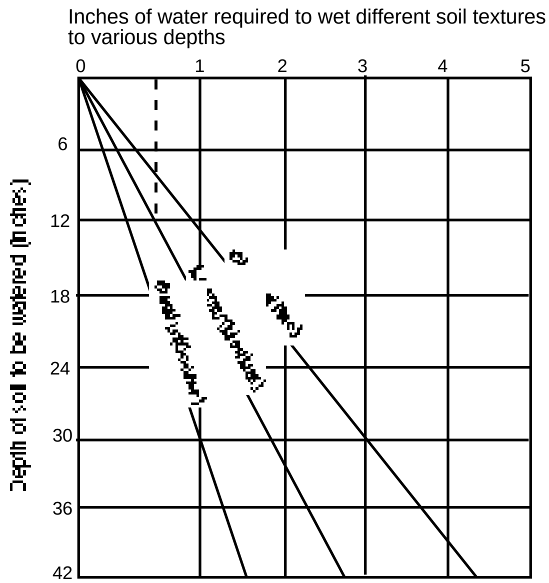
Irrigation aids in the uptake and utilization of nutrients present in the soil. It is most effective in developing sturdy plants with heavy root systems, in reducing “blossom-end-rot,” in activating herbicides and improving the size and shape of tomato fruit.

As growers move more into growing late summer tomatoes, irrigation is more important than for an early crop, due to the reduced rainfall of the late summer.

The proper use of an irrigation system is as important to good yields as the system. Growers must learn to use a system to apply uniform moisture levels throughout the growing season. Ample soil moisture is necessary during the vegetative,

Figure 4

Water Needed to Wet the Effective Rooting Zone of Different Soil Type



Water needed to wet the desired depth (effective rooting zone) of various soil textures.

flowering and fruit set, fruit enlargement and fruit ripening stage. If a deficiency of moisture occurs during these stages, a yield reduction of approximately 25, 52, 43 and 25 percent respectively may result. If rainfall does not supply moisture at the above times, it should be provided through irrigation by adding enough water per week to hold the effective root zone at about 50 percent field capacity. The approximate amount of water to apply and the frequency of application to maintain this moisture level are given in Figures 2 and 3 respectively. Tomatoes have an effective rooting depth of about 20 inches.

To determine the amount of water needed to wet a soil to the effective rooting depth, use the chart in Figure 4. If you wish to wet a loam (medium-textured) soil to the 12-inch depth, move left to right across the chart at the 12-inch depth line. Stop at the diagonal line marked “loamy” (medium). Move upward to the scale at the top. You will see that about 3/4 inch of water is required. Notice the difference in the amount of water required to wet different-textured soils to the same depth.

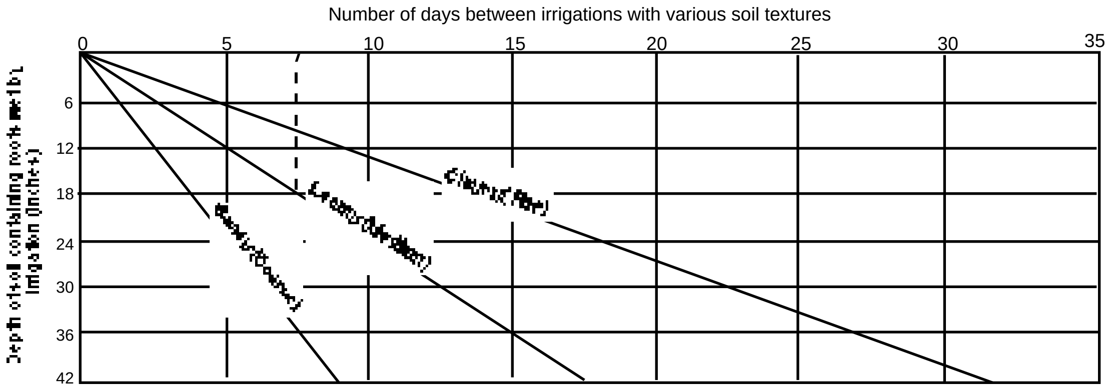
Assume that tomatoes have an effective rooting depth of 18 inches in a loam. You want to wet the soil to this depth when half the available water in that zone has been depleted (Figure 5). Move down the left scale of the chart to the 18-inch line. Follow it to the right to the diagonal line marked loamy (medium). Move upward to the scale at the top. You will notice that you will need to apply water about every seven to eight days to a loamy or medium-textured soil, depending on the wind speed and air temperature.

Irrigation can be supplied either through the use of trickle systems (Figure 6) or through over-the-top sprinkler systems. The trickle system is so designed that it slowly releases water at the base of the plant in the root zone. It places water directly where it is needed and reduces the potential for diseases, since it does not wet the foliage. With this system, water flows through a pipe or tube under very low pressure and is emitted at the desired location. Trickle irrigation will utilize less water than over-the-top sprinkler systems. However, the water source must be very clean and the lines must be equipped with sufficient filtration to remove all soil or mineral deposits in the water supply. If not, line blockage will occur and result in a non-uniform water application. Growers who use plastic are rapidly adopting the trickle irrigation system combined with a fertigation system.

Over-the-top sprinkler systems have been used in the form of traveling guns or stationary units with circulating sprinkler heads. These systems are useful when plastic is not used. They are an effective way to provide the necessary moisture requirements when there is an adequate source available. The

Figure 5

Interval Between Irrigations of Different Soil Types

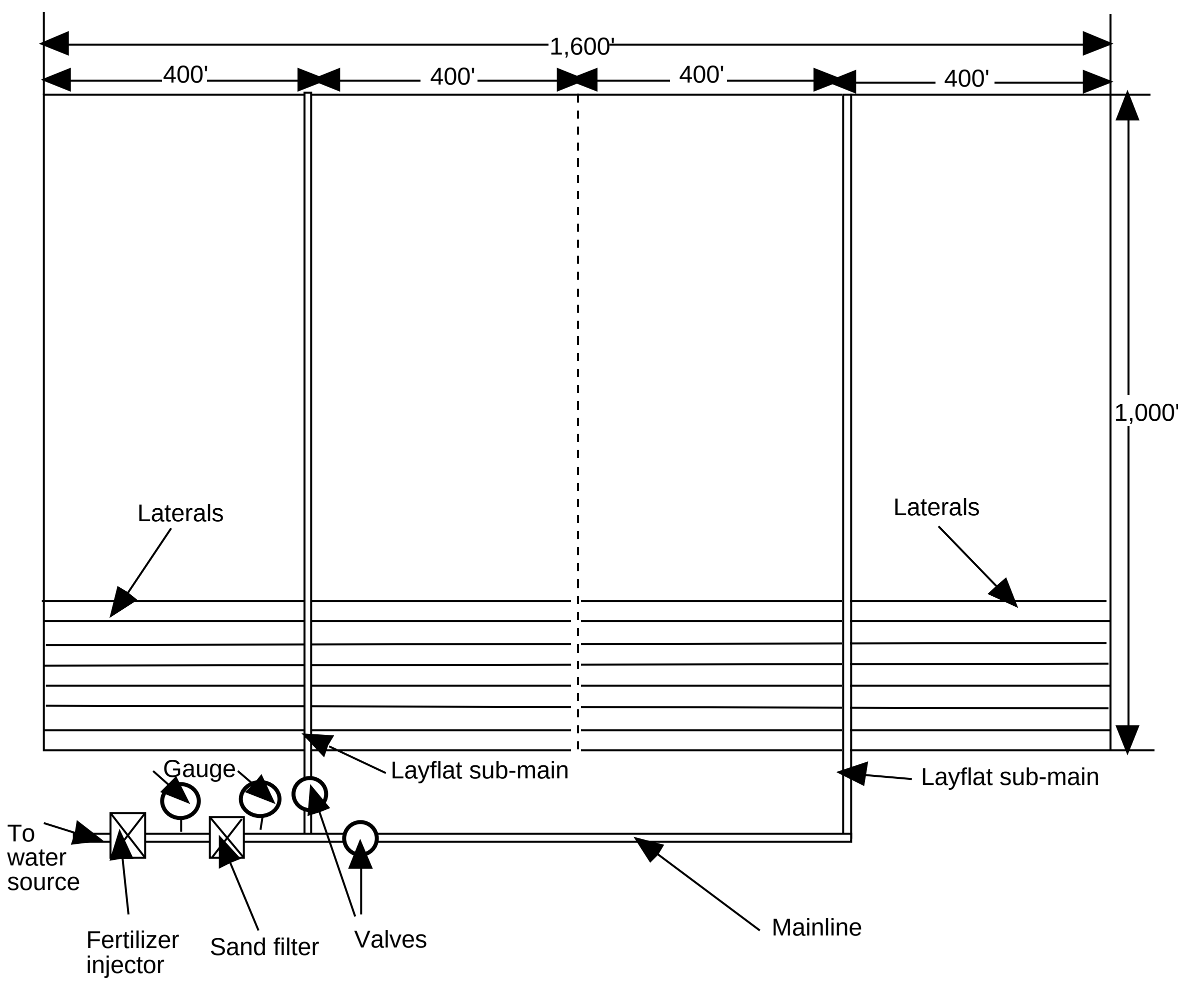


Approximate number of days between irrigations based on a depletion of one-half the available water in the effective rooting zone of soils of different textures.

disadvantages to such systems are the water loss by evaporation, soil crusting problems which occur when water is applied to a clayey soil under high temperatures, and the potential to increase disease by increased wetting of the foliage.

Figure 6

Trickle Irrigation System



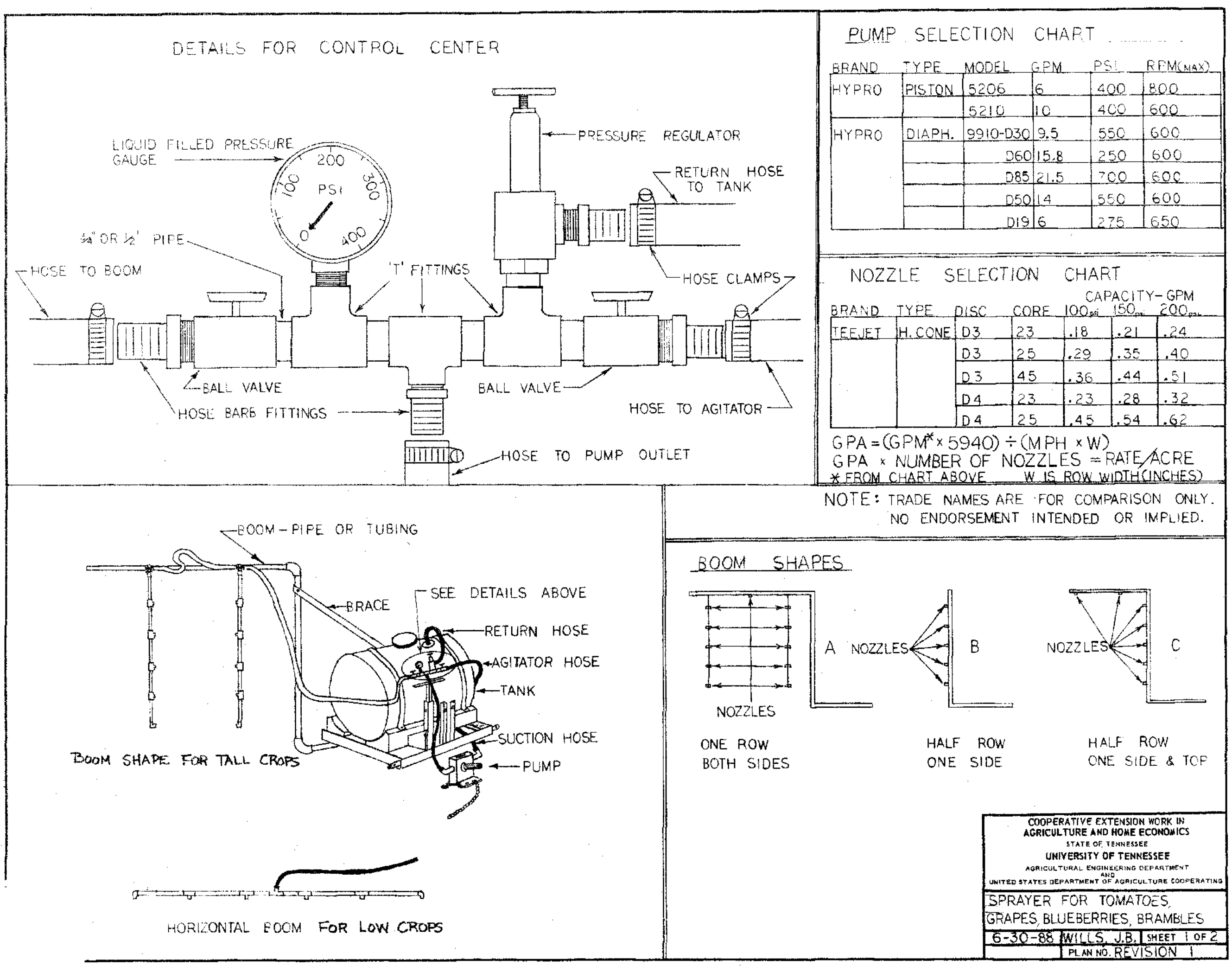
Sprayers

Good disease and insect control is as much a function of the spray equipment used as it is the choice of control chemicals. Sprayers which provide sufficient pressure and movement of spray materials to cover both sides of the leaves and all of the stem and the fruit should be used. A low-volume, low-pressure sprayer equipped with flat-fan nozzles that are used to apply herbicides will not be sufficient to apply fungicides and insecticides. Use it to continue herbicide applications, but arrange for a sprayer which has a pump capable of a pressure of 200-300 pounds per square inch, equipped with cone tip nozzles to apply the necessary fungicides and insecticides. Usually, a piston or diaphragm pump will provide this type of pressure and withstand the rigors of continuous use with wettable powder chemicals. More thorough coverage is obtained when drop nozzles under high pressure are used to spray both sides of a row at one time. Remember that no chemical can provide control if it is not delivered to the target area. A low-volume, low-pressure system that does not roll the leaves will not provide the necessary foliage coverage. Be sure that all nozzles are of the same size, have the same spray pattern and the same size orifice.

Many types of sprayers are available. Back-pack mist blowers and sprayers mounted on two-wheel garden tractors are available for the smaller acreage growers. Some smaller growers have built their own drop-nozzle sprayers which are driven with gasoline motors pulled behind riding lawn mowers. Large-scale growers use large-drop nozzle types mounted on reworked tobacco harvesters, high-boy sprayers or on three-point hitch tractors. All of these types use nozzle tips which break the spray material into a fine mist for thorough foliage coverage from the bottom to the top of the plant.

A drop nozzle sprayer is illustrated in Figure 7.

Figure 7



PUMP SELECTION CHART

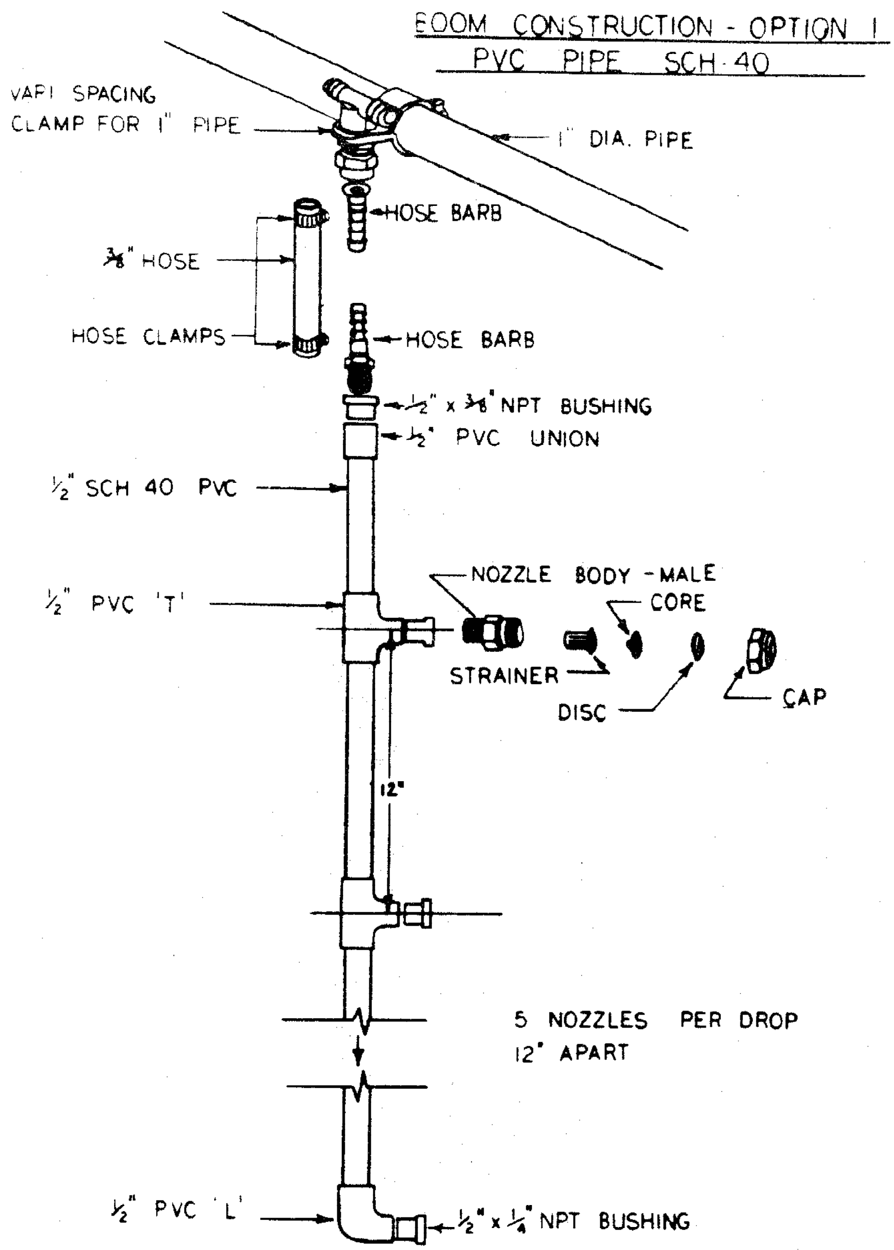
BRAND	TYPE	MODEL	GPM	PSI	RPM(MAX)
HYPRO	PISTON	5206	6	400	800
		5210	10	400	600
HYPRO	DIAPH.	9910-D30	9.5	550	600
		D60	15.8	250	600
		D85	21.5	700	600
		D50	14	550	600
		D19	6	275	650

NOZZLE SELECTION CHART

BRAND	TYPE	DISC	CORE	CAPACITY-GPM 100 psi	150 psi	200 psi
TEEJET	H. CONE	D3	23	.18	.21	.24
		D3	25	.29	.35	.40
		D3	45	.36	.44	.51
		D4	23	.23	.28	.32
		D4	25	.45	.54	.62

Figure 7 (continued)

Drop Nozzle Sprayer



NOTE: SCH 40 PVC IS RATED AT 600 PSI
GLUED AND THREADED JOINTS ARE RATED 300 PSI

Drop nozzle type sprayer necessary to give thorough coverage of tomato foliage.

Applying Pesticides

Using the sprayer described previously, let's look at a practical approach to the correct procedure for applying pesticides to tomatoes. To follow label directions in applying the recommended quantity of pesticides, it is necessary to have an understanding of how row width, tomato plant height and number of operating nozzles per row influence the volume of solution and the amount of materials applied.

The following information provides some insight into these conditions and illustrates how to determine the amount of materials to mix. First, however, some standard conditions must be established. They are:

1. Sprayer speed = 3 mph
2. Pressure = 100 psi
3. Nozzles in operation = From 2 to 6 D3-25 and 2 to 4 D3-23 or other comparable nozzles per row. This depends on the plant height. (Remember, nozzles are located on both sides of the row).
4. Nozzle discharge rate = one D3-23 nozzle discharges 11.9 gallons per acre (gpa) and one D3-25 nozzle discharges 19.1 gpa at 3 mph (264 ft./min.) and 100 psi in a 2.5 foot row*. This discharge rate is converted to 4, 5, 6, 10 and 12-foot row widths and adapted to the number of nozzles that operate as the tomato plant height increases. This information is tabulated in tables 6, 7, 8, 9 and 10.

* This refers to the width of the row area.

NOTE: Final results are given in table 9, if you do not desire to follow the calculations.

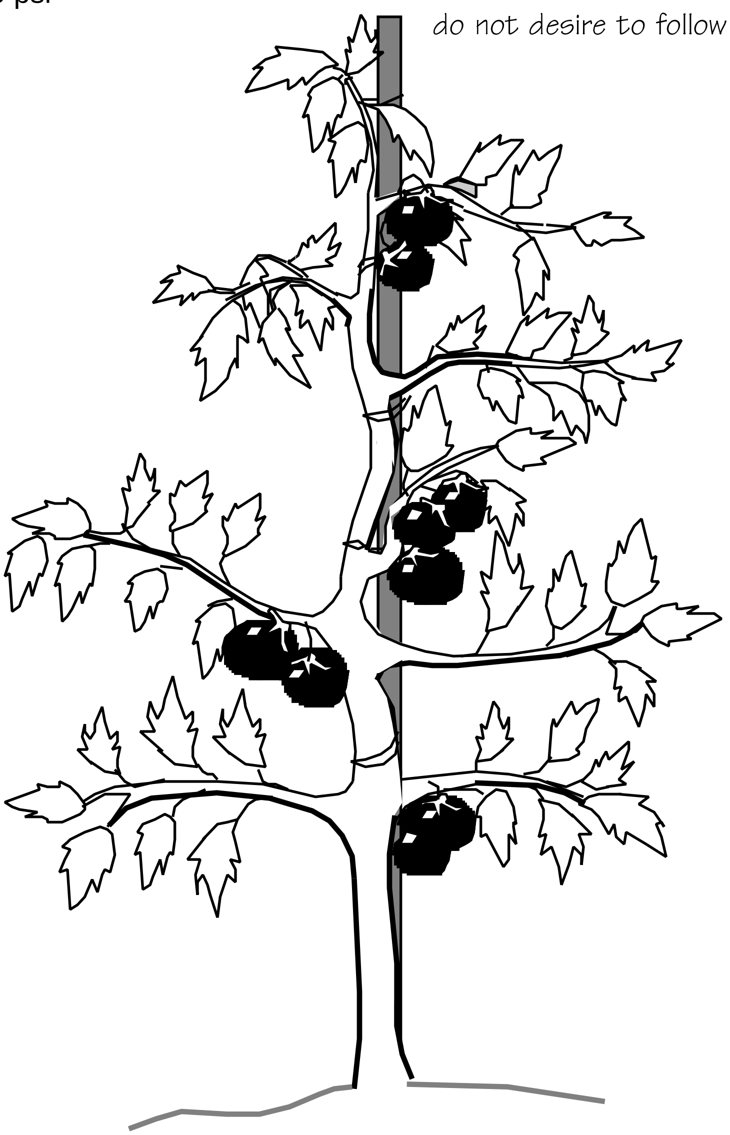


Table 6

Gallons of Spray Solutions Applied Per Acre of Land Using the Standards Specified

Approximate Tomato Height (feet)	Nozzle Type				Total GPA
	D3-25		D3-23		
	Number Operating Per Row	GPA	Number Operating Per Row	GPA	
1	2	38.2	0	0	38.2
2	4	76.4	0	0	76.4
3	6	114.6	0	0	114.6
4	6	114.6	2	23.8	138.4
5	6	114.6	4	47.6	162.2

Converting the discharge rate of 11.9 and 19.1 gpa at 100 PSI and 3 mph in a 2.5 ft.-row to row widths of 4, 5, 6, 10 and 12-foot wide rows, one nozzle will now have the application rates shown in Table 7.

Table 7

Application Rate Per Acre of Each Nozzle at Various Row Widths When Operating at 100 PSI and a Speed of 3 mph

Row Width (feet)	Nozzle Type GPA	
	D3-25	D3-23
4	11.9	7.4
5	9.6	6.0
6	8.0	5.0
10	4.8	2.9
12	3.9	2.5

Note: At constant pressure and speed, the discharge rate for each nozzle remains the same.

It should be pointed out that the total volume applied per plant will be the same regardless of the distance between rows. However, the percentage of an acre sprayed decreases as row width increases (Table 8).

Table 8

Effect of Varying Row Width on the Linear Feet of Row and Percent of an Acre Sprayed

Row Width (feet)	Linear Feet Per Acre	Percent Area Sprayed/Acre of Land
2.5	17,424	100
4	10,890	62.5
5	8,712	50
6	7,260	42
10	4,356	25
12	3,630	21

When the tomato plant height and the number of nozzles being operated at that height are considered, then the total gpa can be determined by multiplying the discharge rate of the nozzle (Table 7) times the number of nozzles being operated at the desired row width. Thus, the total output in gpa is summarized in Table 9.

Table 9

Influence of Plant Height, Number of Operating Nozzles and Row Width on the Total Volume of Pesticides Applied

Approximate Tomato Height (feet)	Number of Nozzles Operating Per Row		Total gpa* per acre at the following row width (feet)				
	D3-25	D3-23	4	5	6	10	12
1	2	0	23.8	19.2	16.0	9.6	7.8
2	4	0	47.6	38.4	31.6	19.2	15.6
3	6	0	71.4	57.6	47.4	28.8	23.9
4	6	2	86.2	69.4	57.2	34.6	28.4
5	6	4	101.0	81.2	67.6	40.4	33.8

* These calculations are based on a speed of 3 mph and a constant pressure of 100 PSI

Operating a sprayer by increasing the number of nozzles enables an increasing spray volume per plant as the plant increases in foliage area.

NOTE: With the nozzles used in this sprayer, decreasing the speed from 3 mph to 2 mph increases the discharge rate per acre by 50 percent. Increasing the speed from 3 mph to 4 mph decreases the rate by 25 percent. Keep this in mind when varying the speed.

How can this information be used?

If a material is to be applied at 2 pounds per acre, the sprayer is operated under the given conditions above, the row width is 6 feet, and the plant height is 3 feet, then 2 pounds should be mixed with each 47.4 gallons of water (Table 9). By the same token, if there is only one-half acre to spray, dividing any of the figures in Table 9 by 2 gives the gallons required to spray the one-half acre.

If a 100-gallon tank is used, the total acres that it will cover at the above conditions are given in Table 10.

Table 10

Influence of Plant Height, Number of Operating Nozzles and Row Width on the Total Acres of Land That Can be Sprayed

Approximate Tomato Height (feet)	Number of Nozzles Operating Per Row		Total acres of land the can be covered with 100 gallons at varying row widths and operating nozzles				
	D3-25	D3-23	4	5	6	10	12
1	2	0	4.2	5.2	6.3	10.4	12.5
2	4	0	2.1	2.6	3.1	5.2	6.3
3	6	0	1.4	1.7	2.1	3.4	4.2
4	6	2	1.2	1.4	1.7	2.8	3.5
5	6	4	1.0	1.2	1.5	2.4	3.0

What should be the pump capacity?

To determine this, the maximum volume per acre (Table 9) to be applied and the time required to spray each acre must be known. If 10 feet between rows is used and the speed is 3 mph, then the time required is 4,356 linear feet/a (Table 8) ÷ 264 ft./min. = 16.5 min./a, excluding turn time. If plants are 5 feet high, then the maximum volume required is 40.4 gpa. Thus, the pump capacity is 40.4 gpa ÷ 16.5 min./a = 2.44 gpm. However, two other factors must be considered; recirculation for agitation and pump wear. Three percent of the tank volume should be allowed for agitation. Thus, 3 gpm should be added to the above 2.44 gpm to take care of agitation. To account for pump wear, utilize 80 percent of the pump capacity. This is done by dividing 5.44 by .80 = 6.8 gpm minimum pump capacity to handle this sprayer.

If more than one row is sprayed, how does that affect pump size?

In that case, multiply the pump capacity required for one row by the total number of rows to be sprayed. If three rows are to be sprayed with the above system, then the required pump capacity is 20.4 gpm (6.8 x 3 = 20.4).

What type pump is desired?

A diaphragm or piston type is preferred because the rollers inside a roller pump will not last with constant use of wettable powders.

Disease Control

Tomato diseases are classified as parasitic and non-parasitic. Parasitic diseases are those caused by living organisms, such as bacteria, fungi, nematodes and viruses. Non-parasitic diseases are caused by unfavorable environmental and nutritional conditions.

Cultural Practices

Losses caused by tomato diseases may be reduced or prevented by the following cultural practices:

- Planting resistant cultivars.
- Use seed that have been both tested for diseases and treated with a fungicide.
- Fumigation or sterilization of seeding and transplant media.
- Rotating crops to reduce disease buildup.
- Using stakes to provide support for plants.
- Following a rigid fungicide and insecticide spray program.
- Maintaining proper soil pH and fertility.
- Mulching.
- Applying nematicides when nematode populations are high.

Fungicides

Fungicides are available for the control of tomato diseases. Weekly applications are usually required. If the label allows, more frequent applications may be necessary during certain weather conditions. The fungicide should thoroughly cover all portions of the plant. Specific chemical controls are listed in Extension PB 1282, *Commercial Vegetable Disease, Insect and Weed Control*, available from your county Agricultural Extension office. Application rates and frequencies of recommended fungicides are included in that publication.

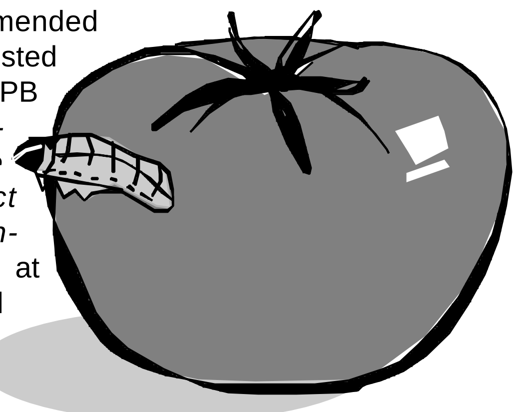
Insect Control

Insect control involves cultural practices and chemical control at the time of seeding, in the plant-bed, in the field before setting and during all phases of field growth.

If insecticides are mixed with other chemicals, care should be taken to avoid incompatibility and phytotoxicity. Apply insecticides using Integrated Pest Management practices as needed at any stage of plant growth. When applied to plant foliage, thorough coverage of plant parts is necessary for good control.

When handling insecticides, growers should pay particular attention to safety precautions required for their use.

Current recommended chemicals are listed in Extension PB 1282, *Commercial Vegetable Disease, Insect and Weed Control*, available at your Agricultural Extension office.



Harvesting

Mature green tomatoes are usually harvested when a white star appears on the blossom end of the fruit. The white star signifies that the seeds are mature and the fruit will develop normal color when exposed to ethylene gas. Usually, three or four harvests are all that is made of mature green tomatoes. Mature green tomatoes are harvested into large bulk bins and then hauled to a packing shed where they are run across a grading machine and separated according to size, color and

A brief description of common parasitic diseases and non-parasitic diseases are as follows:

Parasitic Diseases	
Disease	Description
Diseases of Seedling Tomatoes	
Damping Off	Brown ring girdles the stem at the soil line causing the seedling to shrivel and collapse.
Botrytis	Gray, fuzzy growth on lower stem.
Early Blight	Small, brown circular target-like spots on the leaves and stem.
Bacterial Diseases (canker, spot, speck)	Tiny, pin-head-like dark brown to black spots on the leaves.
Diseases of Field Tomatoes	
Bacterial Spots	Small, raised spots on the fruit. Water soaked-like spots on the foliage.
Early Blight	Small, brown-to-black spots which develop into target-like spots. Spots appear on lower leaves first. Appears as a dark, leathery spot on stem end of fruit.
Septoria Leaf Spot	Small, gray circular leaf spots with dark borders.
Buckeye Fruit Rot	Circular, zonate bands within large spots on the fruit. Worse on lower clusters.
Fusarium Wilt	Yellowing and wilting of foliage. Stem tissue may show brownish internal color.
Gray Mold (botrytis)	Leaves turn brown beginning at the tip and progressing backward. Gray mold on the stem and foliage during humid weather.
Late Blight	Greenish-black water soaked appearing spots on older leaves, increasing rapidly in size and killing much foliage. Disease on fruit appears as a brown, very firm spot. Can result in non-marketable fruit in a week.
Leaf Mold	Yellow spots on upper surface of leaves. Olive to gray mold on the underside of leaves. Found primarily in greenhouses.
Nematode Injury (root knot)	Plants wilt rapidly during periods of moisture stress. Leaves turn yellow and may appear to have nutrient deficiency. Plants are stunted. Galls or knots develop on roots.
Soil Rot (on fruit)	Sunken brown spots 3/4 of 11/4 inches in diameter on fruits. Center of spot usually breaks open.

Southern Blight	Plants wilt and die very rapidly without a distinctive yellowing of the foliage. Stem at the ground line will usually be decayed and covered with a white mold and small light-brown fruiting bodies.
Verticillium Wilt	Foliage will turn yellow and wilt. V-shaped lesions will usually form on leaves. Internal tissue near the base of the plant will usually show brown discoloration.
Non-Parasitic Diseases	
Blossom-end-rot	Tissues at blossom end of fruit become dark, flattened or sunken with a leathery appearing spot. Controlled by supplying adequate amounts of calcium, either by proper liming or foliage sprays and supplying even amounts of moisture. Calcium chloride may be used as a foliage spray at the rate of 4 pounds per 100 gallons of water (4 level tablespoons per gallon) but it is only a temporary correction. Make no more than three applications. Irrigate to maintain uniform soil moisture. Avoid excessive rates of fertilizer.
Catface (or rough fruit)	Fruits deformed by swellings. Masses of scar tissue between swelling. Cavities sometimes extend into fruits. Most common on large fruited cultivars. It is associated with pruning, cold temperatures and wet or dry conditions existing when the flower pistil is developing.
Graywall (or botchy ripening)	Gray to grayish-brown blotches develop on surface of green fruit with an internal browning of outer wall tissues. Common during wet, cool, cloudy conditions.
Growth Cracks	Cracking of fruits at stem ends, extending either around or down the sides of the fruit. Caused by abundant rain and conditions favorable for rapid growth after an unfavorable growth period, such as dry weather. Certain cultivars are more susceptible.
Leaf roll	Leaflet rolling upward and inward at margins. No yellowing or dwarfing of leaves. Little or no stunting of plants. Fruits of normal size and color. Caused by excessive pruning or conditions of low soil moisture favorable for plant growth. There is no apparent reduction in yield. Certain cultivars are likely to show a greater incidence than others.
Pockets — (no puffiness)	Fruits flattened at sides, soft and light in weight. Large cavity between outer wall and center of fruit. Caused by environmental and nutritional factors that interfere with normal pollination and affect the development of seed-bearing tissues.
Sunscald	Large yellow or whitish patches on parts of fruits exposed to sun. Most common on immature, green fruits. Caused by plants defoliated by leaf spot disease or severe pruning, exposing fruits to sunlight.
Walnut wilt	Tops of plants wilt and die when plants are about two-thirds grown. Plant may show discoloration similar to fusarium. Caused by toxin released by walnut tree roots.

defects. They are then placed into 25—pound boxes according to size, placed in the ripening room and then transported to market. Vine-ripe tomatoes are normally harvested about twice per week during the growing season. They are normally packed individually into appropriate containers according to the market demand.

Single and multiple-row harvesting aids are available. A rig built around a small garden tractor is the most common type being produced. Such rigs can be modified (1) to carry two people in one middle with each person "picking" one-half of each row, or (2) to pull a "high-boy" type trailer with riders in three middles. However, large-acreage growers have arranged to have imported laborers harvest by hand.

Small growers have built their own trailers which will seat two pickers and is pulled with a riding lawn mower. This will allow movement down one row and each picker will harvest one-half of a row at a time, placing the fruit in the desired containers. The containers are dropped at each end for pickup.

Post-harvest Treatment

Harvested tomatoes are subject to decay by such diseases as alternaria, buckeye rot, gray mold, soft rot, sour rot and bacterial soft rot. When tomatoes are to be boxed, shipped long distances and left on the shelf for extended periods of time, they should be treated to reduce the potential for decay during these handling procedures.

To reduce the potential for decay, treat the wash water with recommended levels of chlorine. Keep the water clean to reduce effectiveness of chlorine and eliminate the buildup of decay organisms in the water. There are three sources of chlorine that are used. They are chlorine gas, calcium hypochlorite andsodium hypochlorite. The pH of the wash water should be held in the 6.5 to 7.0 range for best effects. The water temperature should be held at about 75F to increase effectiveness. At these pH and

Insects which attack tomatoes are listed in the following table:

Insect	Description
Aphids	Small, soft-bodied, pear-shaped insects with a pair of cornicles (tailpipe-like projections) protruding from the rear end. They may be red, black or green. They may be winged or wingless and feed in colonies on terminals and leaves. Infested leaves often curl and become distorted. Aphids transmit certain viruses.
Colorado Potato Beetles	An oval beetle that is yellowish-brown with five black stripes on each wing cover. The larvae is a yellowish-red or orange, soft grub with black head and legs. Adults and larvae feed on leaves and terminals thus, affecting yield.
Cutworms	The larvae are dark gray to brown and may be solid, striped or spotted with yellow dots. When disturbed, they curl up tightly. Depending on the species, they may reach a length of 2 inches. Cutworms injure seedlings and newly set plants in the field by severing them near the soil surface.
Fleabeetles	Small (1/16 — 1/8 inch) black or striped beetles that jump like fleas. They attack the foliage leaving small, round shot-holes. Damage is most serious early in the season. Potato flea beetles may transmit early blight.
Fruitworms	Adult moths are yellowish-olive. Larvae vary in color from greenish-yellow and reddish-brown or even black with paler stripes running lengthwise along the body. Fruitworms feed on the leaves and fruit and may bore into the stalk.

Insects continued:

Hornworms	The mature larvae are about 3 1/2 inches long, green with seven diagonal stripes or eight V-shaped markings on each side. They possess a prominent horn on the tail section. Larvae strip leaves from the plants and if populations are heavy, they may feed on the fruit.
Leaf miners	The larvae are yellow and about 1/8 inch in length. They tunnel the leaves between the upper and lower surfaces. This damage results in long, white, winding tunnels on the leaves.
Loopers	The larvae are green with several white stripes that run the length of the body. It moves in a characteristic "looping" motion. They feed on the leaves, producing ragged holes.
Tomato Pinworm	The adult moth is gray and has a wingspan of 1/2 inch. The mature larvae may be yellow, green or ash gray and covered with dark purple spots. Pinworms can cause blotchlike leaf mines, folded and tied leaves, pinholes in stems and fruit and fruit blotches.
Spider Mites	Small, yellowish to dark green spiderlike pests that are the size of a pepper flake. They may be detected by dislodging them from the plant onto a piece of white paper and viewed with a 10X magnifying lens. Webbing may be seen over the infested plants. Mites suck the sap from the foliage. Leaves take on a yellowish or bronze cast.
Stinkbugs	Adult stinkbugs are shield-shaped and green or brown. Immature stinkbugs are smaller and may be black or green with orange and black markings, or a solid light color. Adults and nymphs feed with their needle-like mouthparts late in the season. Infested immature fruits or pods may later become deformed. Mature fruit has white areas under the skin.
Wireworms	The larvae are cream to yellowish gray with a reddish-orange head. They are slender, hard and resemble a jointed wire. Wireworms chew ragged holes in the roots. Stems of transplants are most frequently attacked. They are frequent problems when tomatoes are grown after pasture or forage crops.
White Flies	There are several species of white flies. They may vary in certain aspects of body shape such as their wing shape. However, they are all small insects with broad wings covered with fine, snow-white waxy powder. Both adults and nymphs may feed on foliage by sucking juices from the underside of the leaf. They produce a honey dew which may result in a blackening of the leaf. Some species are also very capable of transmitting certain viruses which greatly damage the plant.

temperature ranges, it will require 0.8 and 1.6 pints of 5.25 percent sodium hypochlorite per 100 gallons of water to provide 50 and 100 ppm of chlorine respectively. If 65 percent calcium hypochlorite is used, it will require 1.0 and 2.0 ounces of material respectively added to 100 gallons of water to produce 50 and 100 ppm of chlorine.

Dip the tomatoes in these solutions for four to five minutes to provide control of the decay organisms.

Chlorinated wash water should be drained a minimum of once per day. Some circumstances will dictate that drainage should occur more frequently. However, if chlorination is planned and dumping is expected, it would be wise to check with the local health department to determine if a permit to dump is required. Discharge of such waste water into municipal wastewater treatment plants or into surface water sources may require a permit. Land discharge may also require a permit.

Good practices to follow when using chlorinated water include: (1) monitoring the chlorine concentration and condition of the water, (2) changing the water frequently, (3) avoiding overexposure to chlorine, (4) practicing good sanitation around the water tank and in handling tomatoes, (5) protecting workers exposed to the chlorine and (6) not expecting chlorine to solve all post-harvest decay problems.

Costs and Returns

Production costs vary from area to area depending on spacing, staking, methods of trellising and cultivars. From 200 to 400 labor hours are required per acre of tomatoes. Labor costs range from $1,000 to $2,000 per acre if other than family labor is used. The break-even point is about a 15-ton yield, grossing about $3,000 per acre at 10 cents per pound if 75 percent of harvested tomatoes make market grade. You may evaluate budgets for tomatoes by contacting your Agricultural Extension office and requesting a copy of EC 890, *Planning Budgets for Fruits and Vegetables.*

Costs are reduced as growers become more efficient in methods of production. For this reason, it is recommended that growers start with one-half acre or less and become efficient at this scale rather than starting production on a large scale. Once production and marketing details are worked out, acreage can be expanded as the need arises.

Growers should be aware of price changes and adapt their production to obtain the highest possible prices.

Marketing

In areas of large-volume production, packing houses are operated to grade and market the product. A fee is charged for this service. Growers wishing to market through packing sheds should contact packing shed managers to determine the cultivar required, stage of maturity for harvesting, packing charge, packages required and other helpful information. Some sheds are now equipped to "gas" green tomatoes before shipment. Gassing is becoming more popular in Tennessee as the demand for firm tomatoes used in salad bars increases. Several growers are now operating their own private packing sheds.

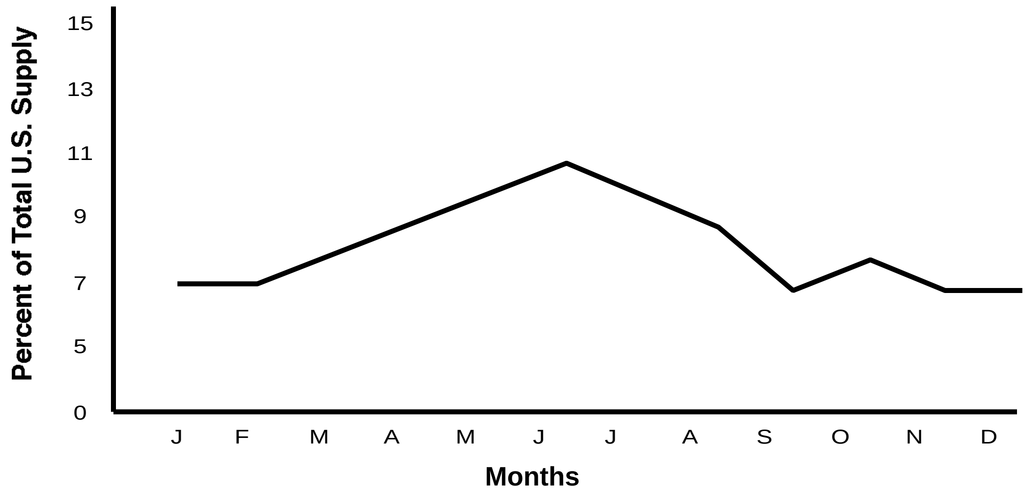
Fresh market growers may sell to local grocery stores, farmers markets, independent buyers and roadside markets. These contacts should be made well in advance of the harvest date. The expected volume, cultivar, size and grade should be specified with the buyer. A high quality product is the key to such outlets. Use high standards when grading and packing the product.

Customer harvesting, or pick-your-own, is an old method of marketing, especially when prices are low. Customers are invited through newspaper ads or radio spots to pick at a given price per pound. Customers usually bring their own containers. Plans for this type of marketing should be made well in advance to provide for parking, check-out stations and other considerations.

One important part of marketing is providing a product when the total supply is low. Usually, when the supply is low, the price will be higher and the potential for making a profit is greater. Figure 8 points out how the total monthly U.S. supply of tomatoes varies. Notice that the supply is low in September compared to that in June and July. Thus, it appears that Tennessee growers who have the correct resources should evaluate the potential for September harvest. Information in this graph was supplied by the United Fresh Fruit and Vegetable Association.

Figure 8

The Percentage the National Supply of Fresh Tomatoes that is Available Monthly



Summary

1. Establish a suitable market. This is the first priority. Keep the market informed of delivery times and amounts. Use packages suitable to the market's needs.
2. Select a cultivar that meets the demands of your particular market. Determinate cultivars are suitable for shipping, while indeterminate types are better adapted to local, fresh market sales.
3. Select plants that have been grown in 2 1/4 inch or larger containers, especially if early yields are important.
4. Take necessary steps to assure that disease-free plants are produced, planted and grown.
5. Select medium-textured soils which provide good root penetration and moisture-holding capacity.
6. Apply lime, phosphate and potassium according to soil test recommendations. Avoid excessive applications to reduce production costs and reduce potential blossom-end-rot problems.
7. Apply nitrogen according to your length of harvest period and available moisture. Late summer tomatoes will not require as heavy nitrogen applications as early tomatoes.
8. Take necessary precautions to avoid frost
9. Space, stake, prune and train according to the cultivar and market.
10. Irrigate if moisture is not supplied by rainfall. One to 1 1/4 inches per week is necessary. Irrigation for late tomatoes is a necessity.
11. Control insects, diseases and weeds by using proven chemical and cultural methods, equipment and time of pesticide application.
12. Harvest at the stage of ripeness that your market requires. A green market does not want pink fruit delivered to the packing shed.
13. Take necessary steps to improve production efficiency and reduce expenses.
14. Constantly study the market to evaluate seasonal trends in prices, supply and changes in consumer demand.

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